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EXECUTIVE SUMMARY

NAVAL FACILITIES ENGINEERING COMMAND
WESTERN DIVISION
HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT

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Encl: (1) Executive Summary, Phase 1A Ecological Risk Assessment dtd 5 July 1994

1. Enclosed is the subject document for your review. It summarizes the preliminary findings of Tasks 1 through 6 of the Phase 1A ecological risk assessment (ERA) at Hunters Point Annex (HPA). A separate task summary report which contains the supporting documentation for this document will be submitted under a separate cover letter. The technical presentation of the Phase 1A ERA is scheduled for 27 July 1994 at 1 pm at California Department of Toxic Substances Control in Berkeley.

2. If you have any questions regarding this matter, please contact Mr. Dave Song, Code 09ER1DS at (415) 244-2561.

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1.0 INTRODUCTION

The purpose of this executive summary is to provide a preliminary communication to regulatory agencies and natural resource trustees of the principal findings of Tasks 1 through 6 of the Hunters Point Annex (HPA) Phase 1A ecological risk assessment (ERA). Specifically, this summary discusses findings that affect the ecological risk of hazardous substances at HPA, identifies major data gaps, and provides recommendations for future ERA-related work necessary to more fully understand the ecological risk at HPA. The findings reported in this executive summary will be discussed in and supported in further detail in the work plan for the forthcoming Phase 1B quantitative ERA at HPA. This executive summary does not supplant the technical presentation previously scheduled for June 10, 1994; this summary is a companion document to the forthcoming task summaries and formal conceptual model analysis. The presentation date for the technical presentation has not yet been established. The task summary reports which contain the supporting documentation for this summary will be issued on July 1, 1994.

The objective of the HPA Phase 1A ERA was to conduct a qualitative evaluation of the potential adverse effects of contaminants at HPA on ecological receptors and to focus quantitative data-gathering efforts in the Phase 1B ERA. In support of this objective, information to support a qualitative ecological risk assessment was collected under six technical tasks. The Phase 1B ERA work plan will be prepared under a separate task. These six technical tasks include the following:

- Task 1: Compile and evaluate facility characteristics
- Task 2: Compile environmental data and identify contaminants of potential concern
- Task 3: Characterize habitats and biota
- Task 4: Compile and evaluate toxicological/ecological effects information for contaminants of potential concern.
- Task 5: Identify contaminant migration pathways and exposure routes
- Task 6: Identify major data gaps and provide recommendations for future work

2.0 TASK 1 - COMPILE AND EVALUATE FACILITY CHARACTERISTICS

The purpose of Task 1 was to identify facility characteristics affecting the potential exposure of ecological receptors to contaminants at HPA. The characteristics that affect exposure include location, geology, hydrogeology, meteorology, San Francisco Bay circulation and off-site contaminant sources, and utility lines such as sanitary sewers and storm drains.

HPA's location on the invaluable estuarine ecosystem of San Francisco Bay is the primary factor influencing ecological risk. The offshore areas of HPA Parcels B, C, D, and E provide a diverse aquatic habitat, and Parcels A, B, and E provide a limited terrestrial habitat. All of the habitat types are disturbed to some degree as a result of shipyard operations. Parcels C and D are almost entirely paved except for small pockets of vegetation which are not considered suitable habitat for animal life. The habitat that is available does support key species that perform important functions in the bay ecosystem as well as species that have been declared threatened, endangered, or are otherwise of concern.

Hazardous substances at HPA include chemicals that may adversely affect the structure and function of both the aquatic and terrestrial habitats. These substances include trace metals, polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), organochlorine pesticides, and tributyltin. The source of this contamination is believed to be shipyard operations.

The subsurface stratigraphy at Parcels B,C,D and E includes three artificial fill units through which hazardous substances may migrate to groundwater: (1) serpentine bedrock-derived fill consisting of gravel and boulder-sized material in a sand and/or clay matrix, (2) industrial fill, and (3) backfill material consisting of poorly graded sands and gravels. Consequently, Parcels B, C, D, and E have a poorly developed soil horizon that is well drained and low in organic matter. Generally, these fill units overlay bay mud deposits. The Parcel A outcrop is a Franciscan melange consisting mainly of serpentinite bedrock, containing some naturally occurring heavy metals.

Parcels A, B, and E are the areas on the base having potential terrestrial habitat.
Parcel A is significantly less developed than the rest of the base and contains areas of relatively dense tree and brush cover in addition to grassy open areas. Conditions for plant and animals inhabitation are more favorable in this parcel than in the other onshore parts of the base, where high heavy metal soil content, poorly developed soil horizon, and shallow depth to saline groundwater limit the composition and abundance of the terrestrial floral community. Consequently, most terrestrial animals at HPA are found in Parcel A. Plant species in Parcels B and E are opportunistic weeds and

herbaceous species adapted to arid conditions, high heavy metal concentrations, and poor soil quality. A limited number and diversity of animal species use the onshore areas of Parcel B.

The offshore property consists of the intertidal and subtidal zones. This marine ecosystem is strongly influenced by bay circulation patterns which resuspend, transport, and deposit sediment particles. Although not well understood, this process may serve to transport sediment-associated contaminants into or away from the underwater property at HPA, specifically at South Basin off of Parcel E and India Basin off of Parcel B. In addition, Yosemite Creek, which drains a large area of commercial and industrial facilities, discharges into South Basin and is a possible source of contaminants in the offshore areas of HPA.

Historical information indicates that the combined storm and sanitary sewer system that discharged to the bay may have been a major pathway by which contaminants reached the offshore areas. Sediments contaminated in this way may have been removed by routine dredging that supported shipyard operations, but no data to support or refute this assumption are available. The storm and sewer systems were separated in the 1970s, and sanitary wastewater is now pumped to an off-site sewage treatment facility. However, the storm sewers may still carry contaminants originating at HPA.

3.0 TASK 2 - COMPILE ENVIRONMENTAL DATA AND IDENTIFY CONTAMINANTS OF POTENTIAL CONCERN

About 600,000 chemical data were collected on soil, groundwater, storm sewer sediment, storm water, bay water, offshore sediment, and mussel tissue. Soil and groundwater data from Parcels B, C, D, and E were analyzed by parcel. Data on contaminated soil at Parcel A were not compiled because the affected soil was removed from the site. Storm sewer, bay water, offshore sediment, and mussel tissue data collected across the facility were analyzed as one group. Where appropriate, the data were compared to regulatory benchmarks to identify chemicals of potential concern (COPC). The information presented below is organized into onshore and offshore sections, and a list of COPC is presented in Table 1.

3.1 ONSHORE DATA

Data on the chemicals present in soils from Parcels B and E were combined, then subdivided into three depth intervals: (1) surface to 0.5 foot, (2) 0.51 feet to 3.0 feet, and (3) 3.1 feet to 10.0 feet. These data were analyzed as described below to identify COPCs for the soil ingestion and soil contact exposure routes. The soil COPCs are presented in Table 1.

Above-groundwater soil data, generally surface to 3.0 feet, for each parcel were compiled and compared to the California Regional Water Quality Control Board (RWQCB) soil values protective of marine water quality (soil values) to identify COPCs for the pathway connecting soil to surface water through groundwater and sediment. This pathway may be complete if contaminants migrate from the soil to the groundwater and then to sediments or surface water. Therefore, these analytes may also be of concern in the sediment ingestion, contact, and respiration exposure routes. The above-groundwater soil data were also evaluated to identify soil "hot-spots" that may be evaluated further for accelerated removal actions. The above-groundwater soil COPCs are listed in Table 1.

Below-groundwater soil data for each parcel were also analyzed to identify COPCs for the pathway connecting soil to surface water through groundwater and sediment. Again this pathway may be complete if contaminants migrate from the soil to the groundwater and then to sediments or surface water. These COPCs may also be applicable to the sediment ingestion, contact, and respiration exposure routes. The below-groundwater soil COPCs are listed in Table 1.

Groundwater data for each parcel were compared to ambient water quality criteria to identify COPCs for the pathway connecting groundwater to surface water through sediment. These COPCs may also be applicable to the sediment ingestion, contact, and respiration exposure routes. The groundwater COPCs are listed in Table 1.

3.2 OFFSHORE DATA

Sediments collected at storm sewer outfalls at each parcel were evaluated to identify toxic compounds that may be discharged to surface waters. The toxins identified included trace metals, cyanide, PAHs, PCBs, and pesticides.

Storm water and surface water data were compared with ambient water quality criteria to identify COPCs for the surface water exposure routes. The toxins detected in these samples included trace metals and organotins. The COPCs for this pathway are listed in Table 1.

Offshore sediment data were compared to NOAA Effects Range Low (ER-L) and Effects Range Medium (ER-M) values, federal sediment quality criteria, and RWQCB wetland creation values to identify COPCs for the sediment exposure routes. The COPCs for sediment are listed in Table 1.

Mussel bioaccumulation data were analyzed to identify chemicals detected in bivalve tissue. Trace metals, tributyltin, PAHs, two PCB congeners, and DDE were detected.

4.0 TASK 3 - CHARACTERIZE HABITATS AND BIOTA

Task 3 consisted of a three-tired characterization of the habitats and biota at HPA:

- Tier I consisted of compiling and evaluating available literature, reviewing local museum collections, and communicating with local scientists on habitats and biota expected and observed at HPA.

- Tier II employed reconnaissance surveys of aquatic and terrestrial environments to provide details on habitat and biota present at HPA.

- Tier III comprised an evaluation of natural history information and modelling of food webs including describing the trophic relationship between the ecological receptors at HPA gathered in Tiers I and II.

Lists of plants and animals observed or expected at HPA were based on literature, field surveys, and interviews with governments agencies, nonprofit groups, and researchers. These tables were submitted to the regulatory agencies in the February 28, 1994, progress meeting. Preliminary terrestrial and aquatic food web models were constructed using information about the feeding habitats of key species.

Terrestrial and aquatic surveys were conducted to identify biota and confirm the presence of wildlife habitat at HPA. The terrestrial survey consisted of site walks. The aquatic survey investigated the composition and abundance of the intertidal, subtidal, epibenthic, and demersal fish communities of the aquatic ecosystem. In addition, qualitative visual and olfactory data were collected from the intertidal and subtidal sediment samples to identify any unique characteristics.

From literature review and field surveys, seven separate habitat types were identified at HPA: (1) ruderal, (2) non-native grassland, (3) landscaped, (4) industrial, (5) wetland (coastal salt marsh), (6) intertidal, and (7) subtidal. All habitats have been disturbed by humans to some degree and contain various amounts of trash, rubble, and potential contamination. A habitat map is presented in Figure 1, and detailed descriptions of each habitat were provided in the February 28, 1994, progress report. Terrestrial and aquatic food web models were constructed from the literature and field data (Figures 2 and 3).

The onshore habitat at HPA supports numerous burrows, apparently dug by small mammals. These mammals may be consumed by mammalian and avian predators. The onshore habitat, especially in Parcels A and E, also provides foraging, nesting, and roosting habitat for various birds, including threatened, endangered, or other species of concern. Most of HPA is covered by pavement and unused industrial buildings. This area was scanned, but was omitted from the more detailed surveys conducted at vegetative areas because of the presumably limited ecological resources present. With little open space for flora and fauna, the area is considered to have little habitat value.

The offshore habitat includes intertidal zones of mudflats and salt marsh and subtidal areas supporting an array of aquatic receptors that form a complex, well-developed food web. During low tide, the intertidal zone provides foraging habitat for migratory and resident shorebirds that consume invertebrates such as bivalves, oligochaetes, polychaetes, crustaceans, gastropods, and chordates. The shorebirds, in turn are preyed upon by the federally endangered peregrine falcon (*Falco peregrinus)*, which has been observed foraging in the adjacent ruderal habitat. At high tides, these invertebrates are also preyed upon by several fish such as silver surfperch (*Hyperprosopon ellipticum*), cheekspot goby (*Ilypnus gilberti*), and white croaker (*Genyonemus lineatas*).

The subtidal habitat surrounding the facility, in particular the shoreline area in Parcel E, is used by numerous birds including the double-crested cormorant (*Phalacrocorax auritus*), California brown pelican (*Pelecanus occidentalis*), and several dabbling and diving ducks. Small fishes, including anchovies (*Anchoa mitchiilli* and *Engraulis mordax*), Pacific herring (*Clupea harengus palasii*), and several gobies, are prey for the California brown pelican, osprey (*Pandion haliaetus*), and carnivorous fish such as leopard shark (*Trakis semifasciata*), smelt (*Atherinopsis sp.*), and California halibut (*Paralichthys californicus*). Marine mammals observed using the bay waters around HPA include the California sea lion (*Zalophus californianus*) and harbor seal (*Phoca vitulina*).

5.0 TASK 4 - COMPILE AND EVALUATE TOXICOLOGICAL/ECOLOGICAL EFFECTS INFORMATION

The contaminants at HPA can be grouped into five classes: (1) trace metals, (2) PAHs, (3) PCBs, (4) organochlorine pesticides, and (5) organotins. The following discussion summarizes the general fate and transport properties and potential adverse effects of these classes of compounds as related to HPA. Detailed toxicological profiles for individual COPCs are presented in the forthcoming Task 4 summary report. Bioaccumulation, growth, reproduction, and survival endpoints were identified. Receptors at the site are exposed to contamination primarily through ingestion of food, soil, and sediment. Therefore, studies in which chemicals were administered in food were preferred over other routes of exposure, such as in drinking water or gavage. However, these selection criteria could not always be met because of the limitations of available data.

5.1 TRACE METALS

The toxicity and bioconcentration of trace metals depend on the bioavailability of the elements in the soil, sediment, and water. Bioavailability is influenced by many factors. These include the physical characteristics of the medium, such as pH, water content (for soils), percent of organic matter, cation exchange capacity, and the ratio of clay to silt and sand; the chemical form, such as the oxidation state; and the presence of other trace elements.

Different heavy metals have different effects on receptors. Most heavy metals, however, have some effect on survival, growth, and reproduction depending on the concentration of those metals. For example, lead is mutagenic, teratogenic, and carcinogenic, it impairs reproductive, kidney, liver, immune, and thyroid functions, and is a metabolic and neurologic toxin. Mercury is also a neurotoxin. Chromium is mutagenic, carcinogenic, and teratogenic to a wide variety of organisms.

Cadmium is also teratogenic and carcinogenic, is a suspected mutagen, and has severe deleterious sublethal effects on wildlife, including acute mortality, reduced growth, and inhibited reproduction.

Because the offshore sediments have acted as a sink for trace metals, toxicity may be evidenced in benthic invertebrates and demersal fish that ingest sediment while foraging for prey. In addition, trace metals could be accumulated by benthic invertebrates and bioconcentrated by higher trophic level predators.

5.2 POLYNUCLEAR AROMATIC HYDROCARBONS (PAH)

The physical and chemical properties of PAHs vary with their molecular weight. As the molecular weight increases, solubility decreases and the potential for partitioning to fatty tissue increases. Most PAHs in aquatic environments are associated with particulate materials. PAHs in aquatic sediments degrade very slowly in the absence of penetrating radiation and oxygen, and may persist indefinitely in oxygen-poor basins or in anoxic sediments.

PAHs cause a wide variety of adverse biological effects in numerous organisms under laboratory conditions, including effects on survival, growth, metabolism, and especially tumor formation. The higher molecular weight PAHs are known to be carcinogenic, mutagenic, and teratogenic to a wide variety of vertebrates, including fish, amphibians, birds, and mammals. The lower molecular weight PAHs are generally not carcinogenic, but are more acutely toxic than their higher molecular weight relatives. PAHs also suppress the immune system, which can often result in increased susceptibility of the animal to disease. Inter- and intraspecific responses to PAHs are quite variable and are modified by interaction with other inorganic and organic compounds, including other PAHs. In general, PAHs show little tendency to biomagnify in food chains, despite their high lipid solubility, probably because most PAHs are rapidly metabolized by organisms.

Because PAHs have concentrated in offshore sediments, the lower molecular weight compounds could be acutely toxic to benthic receptors such as polychaetes and crustaceans. The higher molecular weight compounds may accumulate in primary and secondary consumers such as fish and birds and cause carcinogenic effects. However, PAHs would not be expected to cause adverse effects through food chain transfer to higher trophic level consumers because they generally do not biomagnify.

5.3 POLYCHLORINATED BIPHENYLS (PCB)

PCBs are mixtures of different congeners of chlorobiphenyl, and the relative importance of environmental fate mechanisms depends upon the degree of chlorination. In general, the persistence of the PCB is a function of the degree of chlorination, with the lower-chlorinated biphenyls degrading relatively slowly, and higher-chlorinated biphenyls being resistant to degradation. Most of the PCBs contaminating HPA are the more chlorinated congeners, such as Arochlor-1260 and Arochlor-1248.

PCBs tightly adsorb to soil particles, with adsorption generally increasing with the degree of chlorination. PCBs generally do not leach in aqueous soil systems, but the lower chlorination PCBs have a greater ability to leach than the higher chlorinated PCBs because they are less tightly bound to soil particles.

When released to water, PCBs can volatilize relatively rapidly; however, adsorption to sediment and suspended matter is a more important fate process. Although adsorption can immobilize PCBs for long periods of time, they may eventually become mobile again. All PCB congeners are highly lipophilic, and most are readily distributed to fatty tissues. Lower chlorinated PCBs are more water soluble than their higher chlorinated counterparts. Consequently, PCBs bioconcentrate and biomagnify significantly, especially those with higher degrees of chlorination.

Documented effects of exposure to PCBs in aquatic organisms include decreased growth, reproductive toxicity, mutagenicity, histopathology, and a variety of biochemical perturbations. Generally, avian species are less susceptible to the acute toxic effects of PCBs than mammals. PCBs disrupt normal patterns of growth, reproduction, metabolism, and behavior in birds. PCBs have been implicated as causing eggshell thinning, although the evidence is inconclusive. Documented effects of PCB exposure in mammals include reproductive failure, physiological effects, altered behavior, and mutagenic, carcinogenic, and teratogenic effects.

Adverse ecological effects from PCBs are most likely under relatively long exposure durations for higher trophic level consumers in the sediment-based aquatic food web at HPA. In the terrestrial ecosystem, biomagnification by consumers preying on mammals may also be significant. However, the identity and trophic importance of the population of resident burrowing animals, which could transfer PCBs from soil up the terrestrial food chain, is unknown.

5.4 ORGANOCHLORINE PESTICIDES

The organochlorine pesticides of concern at HPA are DDT and its metabolites (DDE and DDD), chlordane, dieldrin, endrin, endosulfan, and heptachlor. These pesticides generally have low water solubility and strongly bind to organic material. They are extremely persistent in soils and sediments due to their strong adsorption to organic matter and generally do not tend to leach to groundwater. Because these pesticides are soluble in lipids, they also bioconcentrate and biomagnify significantly.

Organochlorine pesticides adversely affect a variety of species' survival, reproduction, and growth. The most well-documented effect of these pesticides on wildlife is eggshell thinning in birds, especially in high trophic-level species. Other deleterious effects on birds include reduced reproductive success, reduced survival, and altered behavior.

Deleterious affects of these insecticides at HPA may also occur in primary receptors such as invertebrates and fish after sufficient exposure. Effects in avifauna may result from biomagnification through aquatic food chains and, probably to a much lesser extent, through consumption of terrestrial mammals that may have accumulated insecticides through the soil ingestion exposure route.

5.5 ORGANOTINS

The only organotin found at HPA is tributyltin (TBT). In the aquatic environment, TBT has a strong tendency to partition to suspended and bottom sediments because of a very high organic carbon partitioning coefficient, making it very persistent in aquatic ecosystems. However, sorption to sediments and particulates is reversible, so organisms in the water column may bioaccumulate tributyltin. TBT will be removed from the system by volatilization, degradation, and bulk transport via currents and tidal action. During degradation, organotins are converted to inorganic tin by the progressive removal of organic groups. UV-photolysis and biological degradation are the major environmental agents of this conversion. Microbial degradation is the primary process by which TBT is removed from estuarine water, and dibutyltin is the major degradation product.

TBT is hydrophobic and soluble in fatty tissue, and easily crosses biological membranes. TBT has been shown to bioconcentrate in fish and algae. Gastropods and bivalves are sensitive to TBT, followed in sensitivity by crustaceans, algae, and fish. TBT is slow acting, and affects development and reproductive functions.

At HPA, TBT is expected to affect survival of benthic invertebrates through long-term exposure from ingestion of sediment particles. TBT in sediment pore water may also be accumulated by filter feeding invertebrates, such as bivalves, from which it may be transferred to bivalve predators, such as crustaceans and birds. In addition, TBT could also bioaccumulate in fish that live and feed at the sediment-water interface.

6.0 TASK 5 - IDENTIFY CONTAMINANT MIGRATION PATHWAYS AND EXPOSURE ROUTES

HPA is a complex site involving both major and minor contaminant migration pathways. The primary and secondary contaminant sources, primary and secondary contaminant transfer mechanisms, and multiple exposure points are summarized below. A detailed discussion of contaminant migration pathways and exposure routes of concern will be presented in the forthcoming Task 5 summary report.

Although a number of primary sources may have contributed to soil, groundwater, and sediment contamination, the principal sources are the onshore contaminated soils, storm water runoff, and offshore sediments. This analysis assumes that airborne deposition of chemicals to HPA is insignificant and that inhalation of contaminants by air-breathing receptors is an insignificant exposure route. The HPA contaminant migration pathways and exposure points are depicted in the general conceptual ecological models for Parcels B, C, D, and E presented in Figures 4 through 7 and summarized below. Note that the following summary addresses all combinations posed by the four models.

The primary sources suspected for soil and groundwater contamination at HPA include the installation restoration (IR) sites, preliminary assessment (PA) sites, and the underground storage tank (UST) sites. The primary mechanisms involving the transfer of hazardous substances include surface deposition from unknown sources, infiltration from primary sources into soil, discharge from primary sources into storm sewers, and discharge from primary sources into sanitary sewers. The secondary sources include contaminated soil, contaminated groundwater polluted as a result of infiltration of soil contamination, and leaking storm sewers and sanitary sewers, which can receive contamination from soil infiltration and groundwater discharges through breaches in piping.

Contaminants in soils may be transferred to ecological receptors along a number of pathways: (1) direct contact, (2) soil erosion, (3) leaching into the groundwater, (4) leaching into stormwater and sewer lines, and (4) surface runoff. The exposure point for all these pathways, except for direct contact, is the aquatic habitat in which the chemical is either retained in the water column or bound to the sediment.

The primary means of exposure of contaminants in groundwater to ecological receptors is the aquatic habitat. Groundwater is in direct contact with the bay along the shore of HPA. Groundwater flow indicates that chemicals in groundwater may be transferred offshore, where they may be bound to the sediments or released to the water column. Utility lines such as storm drains may act as conduits for the groundwater.

Storm water discharges into the bay are a major contaminant migration pathway. Contaminants associated with surface runoff are deposited directly into the storm water systems which flow directly into the bay. Sanitary sewers currently discharge to an off-site wastewater treatment facility. However, it is suspected that some sanitary sewers, possibly receiving discharges from small buildings on base, not have been separated from the storm water systems. In addition, breeches in both the storm water and sewer lines may allow for contaminated soil and groundwater to be transported to the bay.

Contaminant migration in the aquatic environment is driven by tidal and wind currents. The tide and wind-influenced surface waters disturb the top layer of the sediment, causing the chemical equilibrium at the sediment-surface water interface to be in constant flux. In addition, contamination can be transferred on and off Navy property by sediment resuspension and deposition.

Ecological receptors may be exposed to contaminants from four sources: (1) soil, (2) sediment, (3) surface water, and (4) prey. Plants may uptake contaminants through root systems infiltrating contaminated soil. Animals, especially burrowers, may ingest and dermally contact contaminants in soil. Although the groundwater at HPA is contaminated, plants are not expected to contact it because of its salinity. Plants are not equipped to regulate the high concentration of dissolved salts in the groundwater and most likely avoid such a poor water source. Plants may be exposed to contaminants in surface water, which includes cellular absorption by roots and aerial plant parts. Animals may be exposed to contaminants in surface water through ingestion into the gut, respiration via gills or skin, and dermal contact. For the offshore sediment, wetland and aquatic plants may be exposed to sediment-associated contaminants through root systems. Animals can be exposed to sediment-associated contaminants through ingestion of contaminated sediment particles and pore water, through respiration of pore water, and through dermal contact with sediment and pore water. Transfer through the food chain may occur through the ingestion of contaminated plant and animal material.

7.0 TASK 6 - IDENTIFY MAJOR DATA GAPS AND PROVIDE RECOMMENDATIONS FOR FUTURE WORK

The initial objective of Task 6 was to identify major gaps in information that would be addressed in the forthcoming HPA Phase 1B ERA. Two additional objectives were agreed upon by the Navy and the regulatory agencies: (1) prepare general ecological conceptual models and (2) select assessment and measurement endpoints. The following summary of Task 6 consists of a discussion of the following: general ecological conceptual models, assessment and measurement endpoints, major data gaps, and recommendations for future work. A detailed analysis of the conceptual models, endpoints, data gaps, and recommendations will be presented in the forthcoming Task 6 summary report.

7.1 GENERAL ECOLOGICAL CONCEPTUAL MODELS

The general ecological conceptual models for Parcels B, C, D, and E presented in Figures 4 through 7 should be viewed together with the terrestrial and aquatic food webs (Figures 2 and 3). The data indicate that soils and offshore sediments act as both contaminant sinks and contaminant sources. These contaminants may adversely affect the structure and function of the aquatic ecosystem and, to a lesser extent, the terrestrial ecosystem, as the models depict.

In addition to acting as a reservoir of contaminants, the offshore sediments may be receiving contaminants from the groundwater, overland flow, storm water discharges, and other mechanisms, such as circulation and deposition of sediments from other bay sources and input from Yosemite Creek to South Basin. In addition, anoxia in the deeper sediments may prevent or retard contaminant degradation. Through wind, tide, and wave action, contaminants in sediments may become redissolved and/or resuspended into surface water, where they are more readily bioavailable. Contaminants may slowly exfiltrate from the sediment pore water through the sediment-surface water interface into the water column. The chemicals in the water, however, would be expected to undergo significant dilution, potentially minimizing toxicity. Nonetheless, contaminants may still be transferred through the aquatic food web and cause adverse effects at higher trophic levels.

Soil in Parcels B, C, D, and E may be receiving contaminants from various IR, PA, and UST sites. Soil contaminants may be unavailable to biota because the high soil pH (7.7 - 8.4) shifts heavy metal equilibria toward the solid phase. Organic constituents may be bound to organic matter in the soil. However, terrestrial receptors may incidentally ingest or dermally contact contaminated soil. Soil-associated contaminants can migrate through the soil to the groundwater or migrate to the storm sewers. Once reaching the groundwater, contaminants may migrate to the offshore sediments, at which point they become available to ecological receptors. The storm sewers also convey soil contaminants to the surface waters. These substances may precipitate to the sediments by various means.

Food chain transfer is a significant exposure pathway at HPA because much of the contamination in the soil and sediments has high bioaccumulative potential. These contaminants, principally the organochlorine insecticides, biomagnify through trophic transfer and may cause deleterious effects at higher trophic levels. Contaminants that bioaccumulate may also cause adverse ecological effects, such as acute and chronic toxicity, at lower trophic levels. It is difficult to predict which receptors may be affected, since site-specific bioavailability of most contaminants is not known.

7.2 GENERAL DISCUSSION OF FOOD WEBS

The terrestrial community at HPA is a simple ecosystem severely limited by the several soil characteristics. The terrestrial habitat, primarily in Parcels A, B, and E, is dominated by a variety of opportunistic plant species. The richest terrestrial flora is found in the landscaped habitat of Parcel A. The habitat likely provides food for granivorous, omnivorous, and scavenging birds observed in Parcel A. Evidence of burrowing animals has also been found in Parcel A. These burrowing animals may provide a food source for the raptors that are consistently observed in Parcel A, sometimes perching in trees there. The American kestrel, which consumes birds, small mammals, and large insects, and the loggerhead shrike which feeds primarily on large insects have both been observed at HPA and would be expected to forage in Parcel A.

In Parcel B, ornamental plants dominate in the small landscaped area, and small brush is found near the shoreline of India Basin. No mammals have been observed in Parcel B.

The low abundance of flora in Parcel E results from well-drained, nutrient-deficient soil that is rich in heavy metals. The poor habitat in Parcel E limits the faunal diversity. As in Parcel A, flocking birds and burrowing animals may be a source of prey for raptors, like the peregrine falcon, American kestrel and red-shouldered hawk, which have been observed forging in Parcel E. The importance of Parcel E as foraging grounds to these raptors is not known.

The aquatic ecosystem is more complex and diverse than the terrestrial community. Nutrient-releasing decaying organic matter and primary producers, like phytoplankton and algae, form the foundation of the aquatic food web and supply carbon to the primary consumers. Primary consumers, such as zooplankton, crustaceans (amphipods, isopods, and decapods), and annelids (polychaetes and oligochaetes) form an integral prey base for shore birds and fish, especially benthic gobies and other pelagic species. The gobies and pelagic fish are consumed by many species of piscivorous birds and fish and play central ecosystem roles. Top carnivores such as the California halibut, red-shouldered hawk, peregrine falcon, California brown pelican, and osprey may be particularly susceptible to bioaccumulated contaminants transferred up the food chain. Linkage between the terrestrial and aquatic food webs is provided by the red-shouldered hawk and the peregrine falcon, which prey on both terrestrial and aquatic avian receptors.

7.3 PROPOSED ASSESSMENT AND MEASUREMENT ENDPOINTS

The guidance set forth by the U.S. Environmental Protection Agency (EPA) in the document, "Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference" was applied to Hunters Point Annex (HPA) to select assessment and measurement endpoints for the terrestrial and aquatic ecosystems. As defined by the agency (EPA 1989), assessment endpoints are formal expressions of the actual environmental values that are to be protected. Stressors that may adversely affect the assessment endpoints will be evaluated in the course of the ecological risk assessment. Assessment endpoints are environmental characteristics of biological and social significance, such as protection of sensitive habitats or organisms that if found to be significantly affected, would indicate a need for remediation at the site. However, an assessment endpoint is useless unless it can be quantitatively measured in some way. Therefore, an assessment endpoint must be unambiguously defined so that it can be evaluated either through direct quantitative measurement of the assessment endpoint itself or through direct quantitative measurement of measurement endpoints. Often, an assessment endpoint may not be directly measurable, consequently, use of measurement endpoints to predict effects on assessment endpoints is common. A measurement endpoint is a quantifiable environmental characteristic that is directly related to the assessment endpoint. A model is generally used to describe the predictive relationship between the measurement and assessment endpoints.

Assessment and measurement endpoints were selected by applying the EPA criteria to the conditions at HPA (EPA 1989). The assessment endpoints adopted reflect the ecological and social relevance of the organisms and food web interactions in the terrestrial and aquatic ecosystems. Assessment endpoints were chosen to be clearly definable and quantifiable through measurement endpoints. Measurement endpoints were selected based upon their ability to predict effects on assessment endpoints, their low natural variability, and their ability to be readily quantified. Furthermore, ecological and toxicological information gathered in the ERA Tasks 1 through 4 was incorporated into endpoint selection. These site-specific considerations include the occurrence, abundance, feeding behavior, and susceptibility of various receptors, the appropriate or relevant and applicable requirements, spatial and temporal scales of exposure, and exposure pathways. The assessment and measurement endpoints for the terrestrial and aquatic ecosystems at HPA and the specific rationale for selection of each, describing considerations of habitat use at HPA, trophic level, exposure pathway, biological significance, and social and economic value, are presented in detail in the narrative below and summarized in Table 2.

7.3.1 Proposed Terrestrial Endpoints

The protection of habitat for the raptorial species, peregrine falcon (*Falco peregrinus*), American kestrel (*Falco spaverius*), red-shouldered hawk (*Buteo lineatus*), and loggerhead shrike (*Lanius ludovicianus*) living or foraging at HPA with the ultimate goal of protecting regional populations of these birds, was selected as the terrestrial assessment endpoint. All of these birds have been observed using habitat at HPA, and the American kestrel and red-shouldered hawk have both been observed foraging in Parcels A and E; they may also nest in the trees in Parcel A. The precise residence status of these species at HPA is not known; however, the potential exists for these species to use HPA habitat all year. Although the peregrine falcon and red-shouldered hawk forage over large areas, they have been observed at HPA and may consume prey living at the base. The American kestrel and loggerhead shrike have smaller foraging ranges, and if they reside on base, prey from HPA may compose a large portion of their diet.

Each of these birds is a high trophic level carnivore that, through bioaccumulation in the terrestrial food chain, has the potential to be adversely affected by contaminants in the terrestrial environment, especially pesticides and bioconcentrating heavy metals such as mercury, cadmium, and lead. The primary exposure pathway of concern to these raptors is the ingestion of contaminated prey at HPA. Prey, in turn, accumulate pollutants through a variety of pathways, the most important of which is the ingestion of contaminated food and soil.

As depicted in the terrestrial and intertidal assessment and measurement endpoint food webs (Figures 8 and 9), these raptors consume prey from a variety of trophic levels. The peregrine falcon feeds primarily on birds. The granivorous mourning dove, the granivorous and scavenging rock dove, and the omnivorous northern mockingbird and red-winged blackbird are potential peregrine falcon prey species that are abundant in the terrestrial ecosystem at HPA. Some other birds in HPA's aquatic ecosystem that could serve as prey for the peregrine falcon are shorebirds and ducks.

The red-shouldered hawk shares much of the peregrine falcon's prey base, with the addition of small mammals like the Botta pocket gopher, the California meadow vole, and the California black-tailed hare. Black-tailed hares have been observed consistently at HPA; however, the residential status of the gopher and vole is not as definite. Evidence of a burrowing animal, probably a mammal, has been seen in nearly every portion of Parcel E and in some portions of Parcel A, both areas where raptors have been observed foraging. Because the peregrine falcon and the red shouldered hawk may also forage on the margins of the aquatic ecosystem for shorebirds, they represent an important link between the terrestrial and aquatic systems at HPA. The American kestrel also consumes small birds and mammals but also feeds on large insects, which comprise the main prey base for the loggerhead shrike (Figure 8). In seeking to protect the habitat of these raptor populations, some protection for their prey base of birds, mammals, and terrestrial invertebrates is simultaneously afforded.

The raptors' value to society is evidenced by their protection under various federal and state regulations. The peregrine falcon is a state and federally endangered species whose once declining populations have been recently invigorated through an intensive captive breeding and release program under the Endangered Species Act. Protection of local populations of peregrine falcons is crucial to the continued success of this breeding and release program. Loggerhead shrike populations have recently been found to be declining for unknown reasons. Consequently, shrikes are considered a California species of special concern. The red-shouldered hawk is listed on the Audubon Society's Blue List of avian species of special concern. Furthermore, populations of all of these species have important social and economic value through the interest of bird-watchers and visitors to local and state parks who hope to observe these birds.

Measurement endpoints that may be used to evaluate potential effects of terrestrial contaminants on populations of raptors may include tissue residue analysis and bioaccumulation studies of prey at HPA. These data would be used in a food chain bioaccumulation model to predict potential adverse effects of terrestrial contaminants of concern on assessment endpoints. This model would employ bioconcentration factors for these contaminants from the scientific literature to predict potential contaminant levels in HPA raptors based on data obtained through these tissue analysis and bioaccumulation studies. The predicted contaminant levels in raptors would be compared to levels causing deleterious biological effects to determine the potential for contaminants at HPA to pose significant hazards to raptors using habitats at HPA.

Tissue analysis and bioaccumulation studies could be performed on a variety of organisms that represent potential prey for the birds of prey to be protected as assessment endpoints. Data from these studies would be used to develop food web transfer models to predict potential adverse effects on raptors. To measure contaminant bioconcentration on the lower trophic levels, plant bioaccumulation studies could be performed to predict the potential contaminant content in the food of herbivorous prey species like the mourning and rock doves, the gopher, the vole, and the hare. To measure bioconcentration at higher trophic levels, tissue residue or bioaccumulation studies on earthworms, soil arthropods, and soil isopods could be performed. These studies would provide direct measurements of the potential contaminant concentrations of prey consumed by the loggerhead shrike.

Indirect measurements of potential contaminant concentrations of prey consumed by raptors could be made through a food web transfer model incorporating the soil invertebrate tissue residue and bioaccumulation data. The food web transfer model would trace the potential biomagnification of contaminants from the soil invertebrates, to carnivorous avian species, and finally to the raptors consuming these avian prey. Some of these carnivorous avian prey species are the northern mockingbird, red-winged blackbird, and western meadowlark. Comparison of the potential contaminant content of these prey with adverse effects reported at dietary concentrations would indicate whether raptors at HPA are exposed to excessive contaminant levels through their prey. Another source of information on potential contaminant levels in the diet of the raptor species would come from tissue residue and bioaccumulation studies performed on mourning and rock doves and small mammals.

7.3.2 Proposed Aquatic Endpoints

Because the aquatic ecosystem is more complex than the terrestrial ecosystem at HPA, assessment endpoints representing different taxa were chosen. The protection of habitat for the avian species California brown pelican (*Pelecanus occidentalis californicus*), double-crested cormorant (*Phalocrocorax auritus*), Barrow's goldeneye (*Bucephala islandica*), and great blue heron (*Ardea herodias*) living or foraging at HPA, with the ultimate goal of protecting regional populations of these birds, was selected as one assessment endpoint in the aquatic ecosystem. The protection of local populations of the California halibut and the goby species such as yellowfin goby (*Acanthogobius* *flavimanus*), arrow goby (*Clevelandia ios*), cheekspot goby (*Ilypnus gilberti*), bay goby (*Lepidogobius lepidus*), and of the mollusks and crustaceans of the intertidal and subtidal areas was also selected as an assessment endpoint for the aquatic ecosystem. Some of these species are important prey species for a wide variety of bay fish and birds. Although several species of pelagic fish, like Pacific herring (*Clupea pallasi*), northern anchovy (*Engraulis mordax*), threadfin shad (*Dorosoma petenese*), and smelt species, are consistently observed in HPA waters, are pivotal components of the intertidal and subtidal communities there, and are commercially and socially important, these fish were not selected as assessment or measurement endpoints. Their high degree of mobility lessens their potential susceptibility to contaminant conditions at HPA.

All of the avian assessment endpoint species are consistently observed using habitat at HPA, principally in the Parcel E shoreline and the open water off Parcels B, C, D, and E. The pelican and the goldeneye are both migratory birds that are seasonal residents or visitors at HPA. The pelicans arrive in the bay area to nest during the spring and remain into early fall, whereas the goldeneye is present mainly during winter months to feed. Furthermore, the pelican can range over large areas in search of prey. Despite their seasonal presence and potential mobility, the biological and social value of the pelican and goldeneye is significant enough to warrant designation as assessment endpoints, as described below. The precise residence status and mobility of the great blue heron at HPA is not known, although it has been consistently observed there during the winter. The cormorants appear to be year-round residents, making their potential exposure duration long.

The pelican, cormorant, and heron are high trophic level carnivores whose susceptibility to deleterious effects caused by bioconcentrated contaminants is well documented. The primary exposure pathways of concern for these birds would be ingestion of contaminated prey and sediment. As shown in the intertidal food web (Figure 9), the primary prey bases for these birds are fishes, which are known to bioaccumulate pollutants from both sediment and water and from ingestion of contaminated food.

In parallel to the selection of terrestrial endpoints, these piscivorous birds were designated as aquatic assessment endpoints not only for their susceptibility, but also for their biological importance as high level consumers and for the protective advantages conferred on their prey as a result of this endpoint designation. As depicted in the intertidal food web (Figure 9), the pelican feeds on a variety of fish, most notably pelagic and higher trophic level carnivorous fish. The cormorant and the heron's diets of pelagic fish and gobies, two taxa abundant at HPA, is supplemented occasionally with invertebrates. These fish populations would benefit from efforts made to protect habitats for these predatory birds. Furthermore, some of these fish and invertebrate prey are also assessment endpoints themselves, as discussed below.

Barrow's goldeneye, though not a high level carnivore like the pelican, cormorant, or heron, is biologically important at HPA because it functions as both predator and prey. The prey base of Barrow's goldeneye differs from those of the pelican, cormorant, and heron, because it consumes primarily mollusks and crustaceans, two taxa forming a critical foundation for the health of aquatic ecosystems. Abundant potential mollusk and crustacean prey species are presented in Table 3. These invertebrates are known to bioaccumulate contaminants from both the sediment and the water column and represent important vehicles for bioconcentration in the aquatic food chain. Once again, protecting habitat for Barrow's goldeneye would also confer some protection on its prey. Moreover, ducks like the goldeneye are preyed upon by raptors.

These birds' value to society is evidenced by their protection under various California and federal regulations. The California brown pelican, like the peregrine falcon, is a federal and state endangered species whose once declining populations are now making a significant resurgence in numbers. Protection of habitats for local populations of pelicans is integral to the reestablishment of pelicans in California. The double-crested cormorant and Barrow's goldeneye are both designated under California regulation as species of special concern to be monitored by the California Department of Fish and Game (CDFG). Although not protected under any regulations other than that for California native species, the great blue heron, as well as the pelican, cormorant, and goldeneye, is socially and economically important to bird-watchers and to visitors to local and state parks hoping to see these birds. Additionally, the goldeneye is a harvested game species, making it economically and socially important as a result of human consumption and the sale of game permits.

The protection of local populations of the benthic California halibut and the goby species, such as yellowfin goby (*Acanthogobius flavimanus*), arrow goby (*Clevelandia ios*), cheekspot goby (*Ilypnus gilberti*), bay goby (*Lepidogobius lepidus*), was chosen as an aquatic assessment endpoint for several reasons. First, both species have been caught in HPA waters, and the gobies occur at HPA in abundance. Second, these species' relative immobility makes them more susceptible to potential effects of contaminants at HPA, especially, for example, when compared to more mobile pelagic fish. Halibut spend much of their lives in bays and estuaries, but can migrate to nearshore ocean coastal waters to spawn during the spring. Gobies live in burrows and do not have a large range.

Third, these benthic species's susceptibility is further increased as a result of their ability to bioaccumulate contaminants from a variety of pathways, most importantly, through ingestion of contaminated food and sediment and through contact with contaminated sediment. Both of these fish live and feed on the bay floor. The halibut partially buries itself in the sediment as camouflage, and the gobies share burrows with burrowing polychaetes and other invertebrates. Because these fish are benthic and spend most of their lives in, on, or very close to the bay floor sediments, exposure to any contaminants in the sediment would be significant. Furthermore, the halibut, as a high trophic level carnivore, consumes other benthic species such as bottom-dwelling flat fish, crustaceans, and annelids, all of which are prey that have high exposure potential due to their intimate association with bay sediments.

Fourth, both halibut and gobies play important ecological roles in the intertidal and subtidal communities at HPA (Figure 9). Halibuts are high trophic level carnivores that would be susceptible to contaminants bioconcentrated in the food chain. Conversely, gobies play a pivotal role in the subtidal and intertidal communities as common prey species for many carnivorous piscivorous fish and birds. Halibut are an important commercially harvested fish. Gobies are not harvested; however, their economic importance lies in their central role as prey, supporting populations of many other harvested fish.

The protection of local populations of intertidal and subtidal mollusks, crustaceans, and annelids was selected as another assessment endpoint to complement the aquatic assessment endpoints representing other taxa. Table 2 presents the top 25 percent most abundant intertidal and subtidal invertebrates caught at HPA and describes important aspects of their feeding and life modes that were incorporated into the analysis of these invertebrates' importance as endpoints at HPA. Although occupying a low trophic level (Figure 9), these invertebrates, especially many filter-feeding and sediment-consuming mollusks, crustaceans, and annelids, bioconcentrate contaminants to levels several times greater than those in sediment and water, primarily as a result of feeding behavior. The major exposure pathways for these species are ingestion of contaminated food and ingestion of contaminants from water and sediment.

Like gobies, the intertidal mollusks, crustaceans, and annelids also perform a central ecosystem function as common prey species, as depicted in the intertidal food web (Figure 9). Mollusks, such as clams, mussels, and other bivalves, crustaceans, such as amphipods, isopods, copepods, and decapods (crabs and shrimp), and annelids, such as oligochaetes and polychaetes, are consumed by many bird species, including shorebirds, waders, and diving ducks, in addition to those discussed above as assessment endpoints. Some of these birds are themselves preyed upon by other higher trophic level consumers, such as the peregrine falcon and red-shouldered hawk.

Many commercially important fish species, including pelagic fish, flatfish, and other harvested bay fishes, consume crustaceans, especially decapods, amphipods, isopods, and copepods. Preservation and improvement of the productivity of the bay fishery requires protection of these invertebrate communities, making them biologically, economically, and socially notable. Several of these invertebrates, including crabs, shrimps, mussels, oysters, and others, were once extensively harvested themselves, and efforts to protect these invertebrates may enable a viable fishery to redevelop in the future.

Additionally, these invertebrates were designated as assessment endpoints because their relative immobility makes them good indicators of contaminant conditions at HPA. This fact, combined with the existence of standardized effects tests for these invertebrates, also enables them to be used as indicator species in measurement endpoints. Measurement endpoints that could be used to gauge effects of sediment contaminants on assessment endpoints are toxicity, growth and reproduction, bioaccumulation, and tissue residue tests on bivalves, amphipods, and fish (gobies and, possibly, flat fish). Toxicity, growth, and reproduction tests would provide data on the potential direct effects of contaminants on invertebrate and fish assessment endpoints.

Bioaccumulation and tissue residue studies would provide data with which to build models to predict potential effects on higher trophic level assessment endpoints. The bioaccumulation and tissue residue studies on mollusks and crustaceans would be used to model food chain bioaccumulation potential for contaminants. These data on mollusks and crustaceans would also predict contaminant concentrations in the diets of predators of these species, such as shorebirds and carnivorous fishes, allowing extrapolation to potential effects on higher trophic level assessment endpoints using bioconcentration factors and contaminant effect levels.

7.4 DATA GAPS

To complete the HPA ERA, additional information is needed regarding: (1) the relationship between onshore contamination and offshore contamination and (2) sediment characteristics that influence contaminant bioavailability and toxicity. These two areas are described in the sections that follow.

7.4.1 Relationship Between Onshore Contamination and Offshore Contamination

Data gaps exist concerning the extent of contamination of onshore areas at HPA and any relationship between these onshore sources and offshore contamination and are described below:

- What is the extent of contamination around soil hot-spots and the probability of a complete contaminate migration pathway between the hot-spots and the offshore sediments?

- Whether oil observed and strong petroleum odor detected offshore of IR3, IR2, and IR1 are originating from HPA sources?

- Whether identified sediment hot-spots can be attributed to HPA activities?

- What is the contribution of contamination from Yosemite Creek, Islais Creek, Pier 80, combined sewer overflows, and other land and bay sources to HPA underwater property?

- What is the extent to which ecological receptors are exposed to contaminated groundwater from both on-site springs and on-site downgradient groundwater flow to the bay from on-site?

7.4.2 Sediment Characteristics

Information is needed to provide a better understanding of how those sediment characteristics that affect the function of the biotic communities relate to contaminant bioavailability and toxicity. This knowledge will provide the means to better understand how contaminants may affect the structure and function of the biotic ecosystem and the probability of an adverse ecological effect. The following data gaps have been identified:

- What are the sediment characteristics such as pH, total organic carbon, grain size, oxygen, ammonia and sulfide levels that affect sediment toxicity and whether contaminants are bioavailable to key communities in the aquatic ecosystem?
- What are the physical, chemical, and biological factors such as temperature and partitioning coefficients affecting the equilibrium of contaminants between the solid phase (particle) and liquid phase (pore water)?
- To what degree are sediment-associated contaminants available to primary receptors at HPA, such as benthic macroinvertebrates that ingest, contact, or respire sediment particles and/or sediment pore water?
- To what degree are sediment-associated contaminants available to receptors such as demersal fish and diving birds that incidentally ingest sediment particles?
- What are the major mechanisms responsible for removal of PCBs, PAHs, and organotins from offshore sediments?
- What is the extent of transfer of contaminants to higher trophic level consumers such as birds and carnivorous fish?
- What is the adverse effect of contaminants on benthic macroinvertebrates and the secondary effect on consumers of the macroinvertebrates?
- What is the adverse effect of contaminants on higher trophic level consumers such as birds and carnivorous fish?
- What is the ratio of aquatic to terrestrial prey in the red-shouldered hawk and peregrine falcon?
- What is the duration of exposure to contaminants by key receptors?
- What are the site-specific bioaccumulation/bioconcentration factors for key receptors?
- What are the site-specific contaminant tissue levels in terrestrial receptors.

7.5 PROPOSED RECOMMENDATIONS

To address the gaps in information concerning the extent of contamination of onshore areas at HPA and the relationship between onshore sources and offshore contamination, the following information should be collected:

- The ambient level concentrations should be identified. Characterize risk at areas above ambient levels.

- Develop risk factors for the COPCs. Rank the COPCs to determine the chemicals of concern driving the ecological risk.

- Groundwater may serve as a pathway by which contaminants could reach the intertidal sediments. Intertidal, subtidal, groundwater, and soil data should be examined to determine whether the intertidal area, subtidal area, groundwater, and soil share similar fingerprints.

- Surface water and sediment samples should be collected from Yosemite Creek to assess whether the creek is a significant source of the contaminants detected in South Basin. Similarly, surface water and sediment data from Pier 80 and Islais Creek channel should be evaluated to assess whether they are a significant source of the contaminants found at HPA.

- Further discussion between the regulatory agencies and the Navy is required to address the issue of intra-bay contaminant transport and deposition to HPA underwater property.

- Information collected from the reference stations used in the ESAP program and aquatic surveys conducted in the HPA Phase 1A indicate that "clean" sediment sites in the bay may be as contaminated as HPA. Physical, chemical, and biological information about San Francisco Bay reference stations should be evaluated to provide an overall picture of the status of "clean" sites around the bay. This information may help provide a context in which HPA may be viewed to determine which HPA contaminants should be addressed in greater detail.

The following recommendations are offered to address information that is needed to identify and evaluate the major sediment characteristics at HPA that affect the aquatic ecosystem and the potential for contaminants at HPA to induce adverse ecological effects.

- Numerous contaminants in soil, sediment, and groundwater at HPA that may cause an adverse effect to ecological receptors. To provide a more detailed understanding of how the contaminants may affect receptors, conceptual ecological models should be prepared for each class of the contaminants at HPA, including trace metals, PAHs, PCBs, organochlorine pesticides, and organotins.

- The existing HPA database should be sorted for data on sediment characteristics, such as grain size, pH, organic carbon, oxygen, sulfide, and ammonia levels, that affect bioavailability and toxicity of sediment-associated contaminants. Existing literature should be reviewed to identify other factors at HPA that may affect contaminant bioavailability. Additional data on these characteristics should be collected from HPA sediments. Simple models describing how these factors affect contaminant bioavailability at HPA should be prepared. The bioavailability models should be used to predict the bioavailability of the contaminants in the offshore sediments.

- Equilibrium of contaminants between the solid phase and liquid phase of sediments should be investigated using simple laboratory techniques to determine how contaminants are partitioning in the offshore sediments at HPA. These results should be used identify the appropriate laboratory tools, such as bioassays, for measuring adverse effects of contaminants on ecological receptors.

- Bioavailability predictions should be confirmed by collecting additional empirical data, such as bioassays coupled with chemical analyses and regression techniques, to determine the contaminants responsible for adverse responses of organisms.

- The duration of exposure of key receptors to contaminants should be determined using available literature information and existing information about the ecosystems at HPA.

- To the extent feasible, site specific tissue/organ/body burden data should be collected from species thought to be important links in the aquatic food web. This could be accomplished by using field or laboratory techniques, resulting in relevant contaminant bioconcentration factors. Body burden of contaminants should be coupled with bioconcentration factors to predict contaminant concentrations expected in key high trophic level receptors.

- Develop exposure profiles for each COPC.

- Predicted tissue/organ/body burdens of contaminants in high trophic level receptors should be compared to literature information to identify potential adverse effects. This information should be integrated with contaminant exposure and relevant life history information to predict the probability of adverse effects occurring.

- Simple laboratory techniques should be used to determine the degradation rates of biodegradable contaminants such as PCBs, PAHs, and organotins.

For the HPA terrestrial ecosystem , information on the burdens of contaminants in mammal and bird receptors eaten by raptors should be collected. This could be accomplished using field and laboratory techniques. In addition, more detailed information on the diet of raptors at HPA is needed to determine the proportion of terrestrial-based and aquatic-based diets.

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N00217.003012
HUNTERS POINT
SSIC NO. 5090.3

FIGURE

EXECUTIVE SUMMARY
PHASE 1A ECOLOGICAL RISK ASSESSMENT

DATED 21JUNE 1994

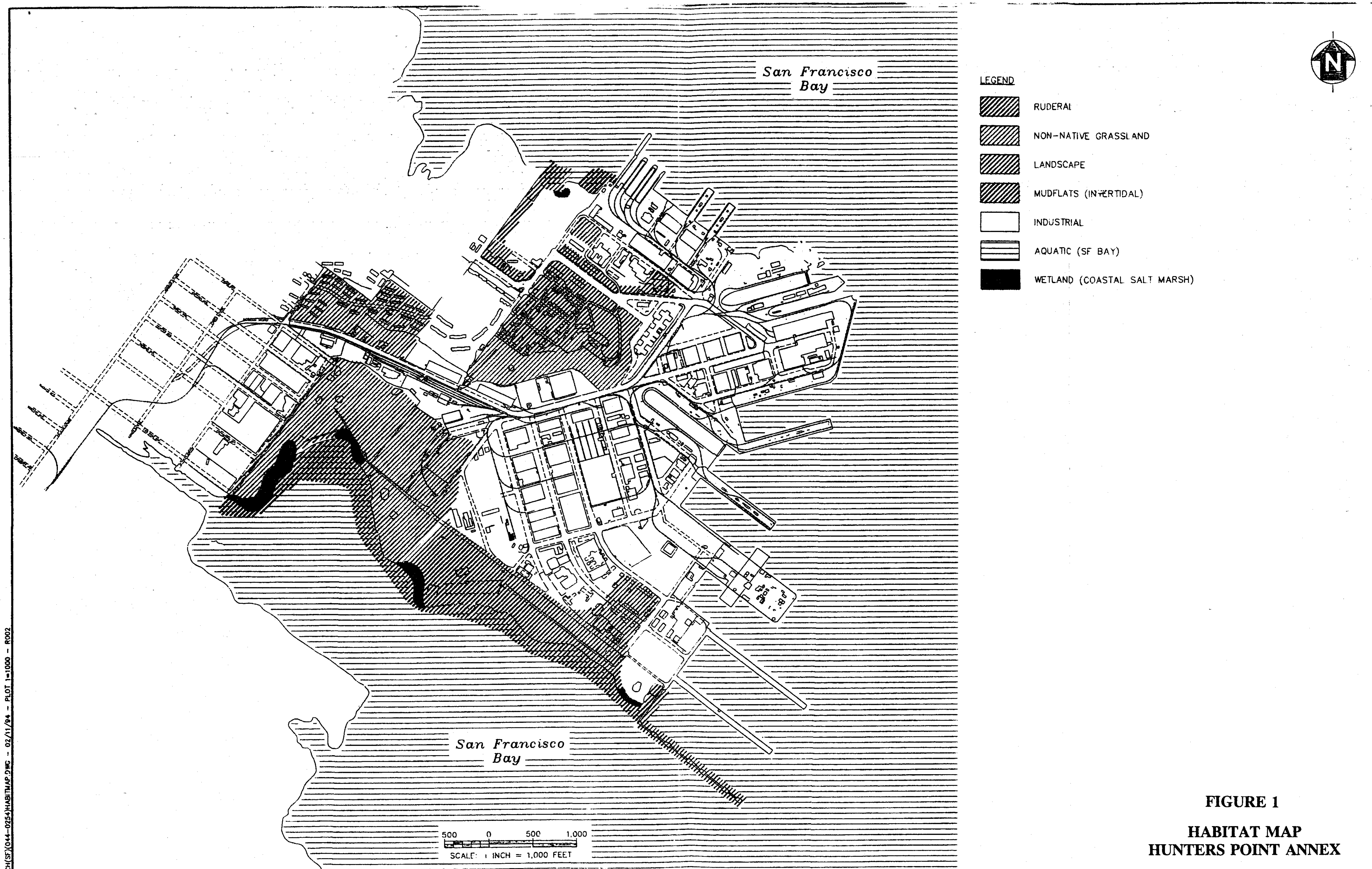

FIGURE 1

HABITAT MAP
HUNTERS POINT ANNEX

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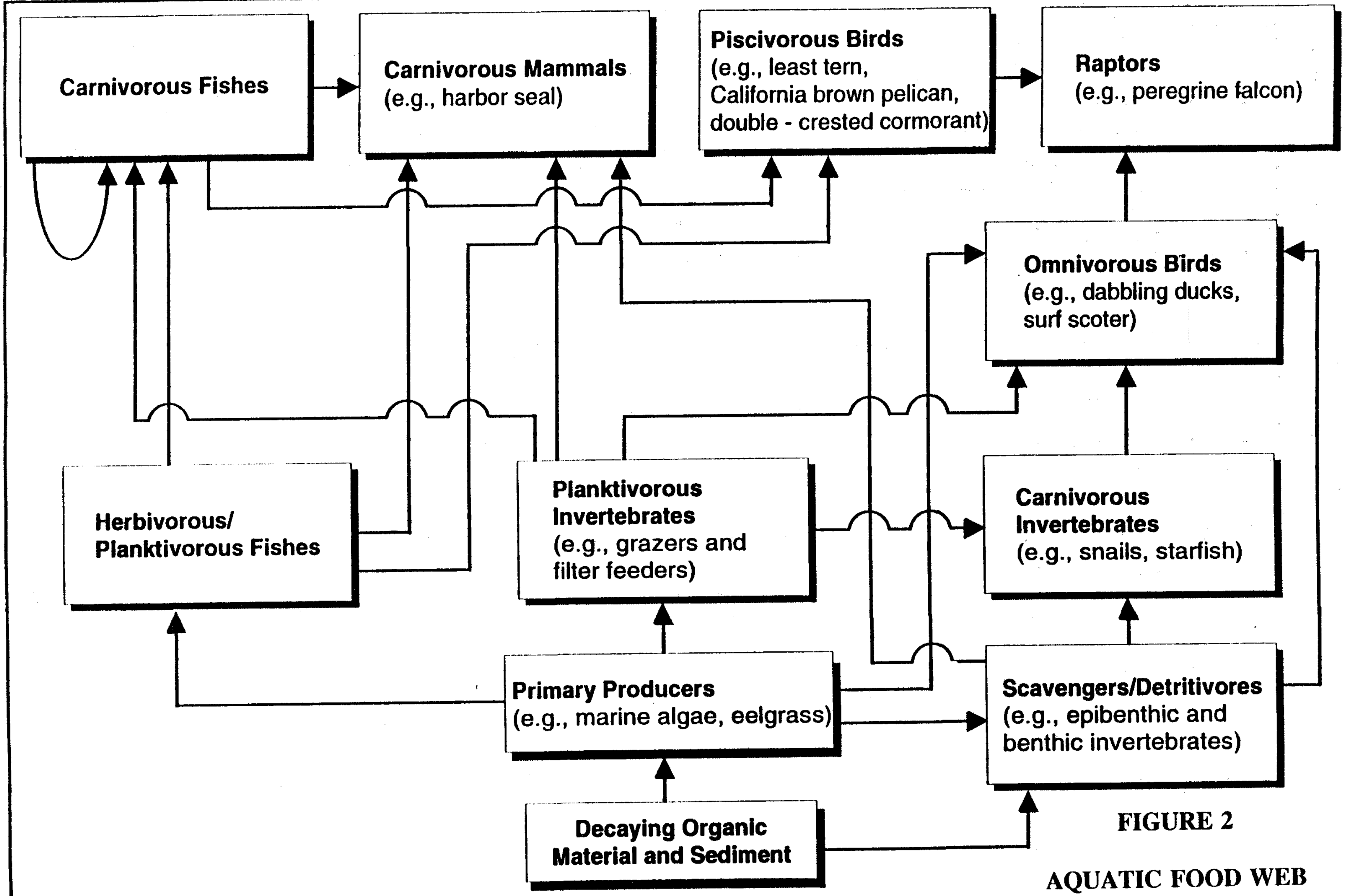

FIGURE 2

AQUATIC FOOD WEB
HUNTERS POINT ANNEX

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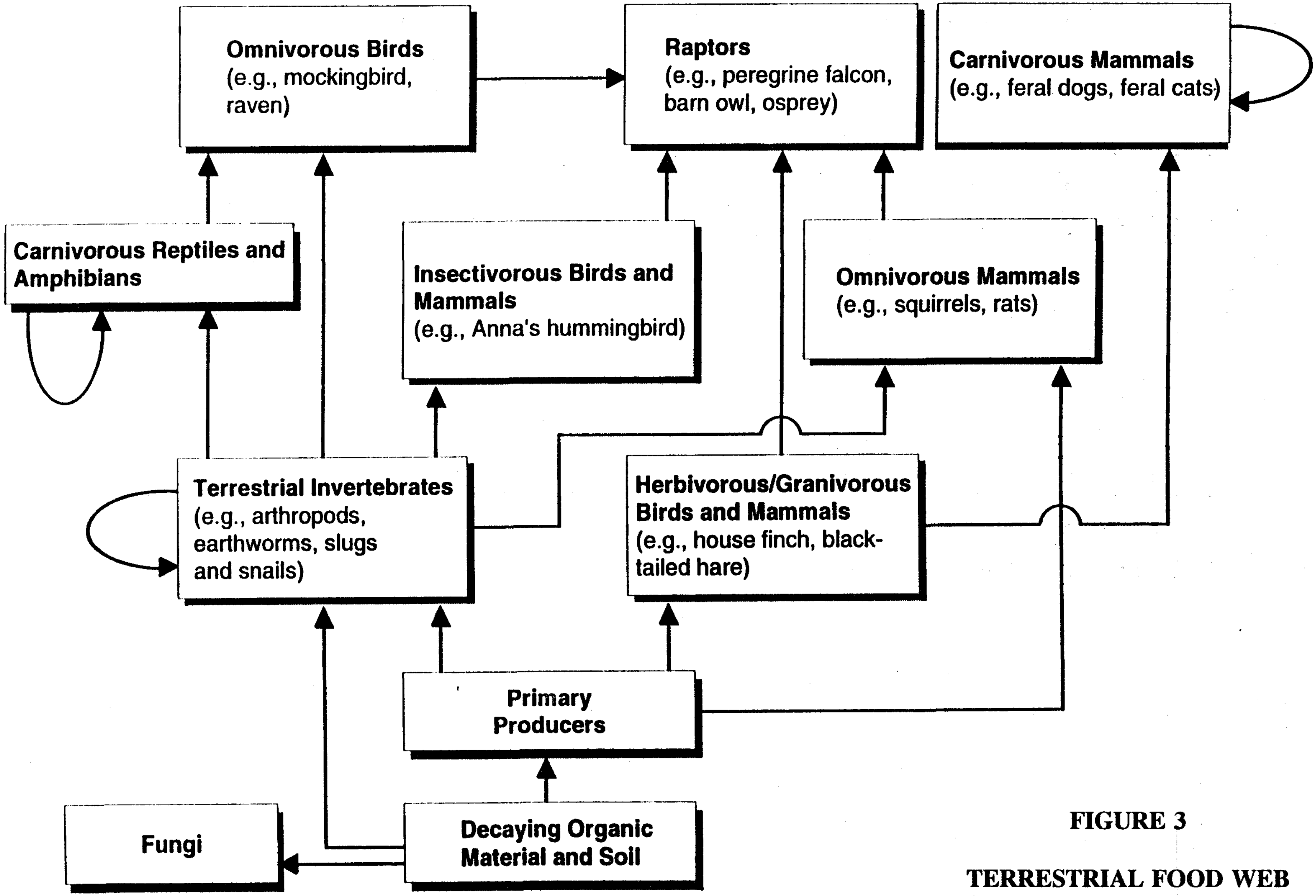
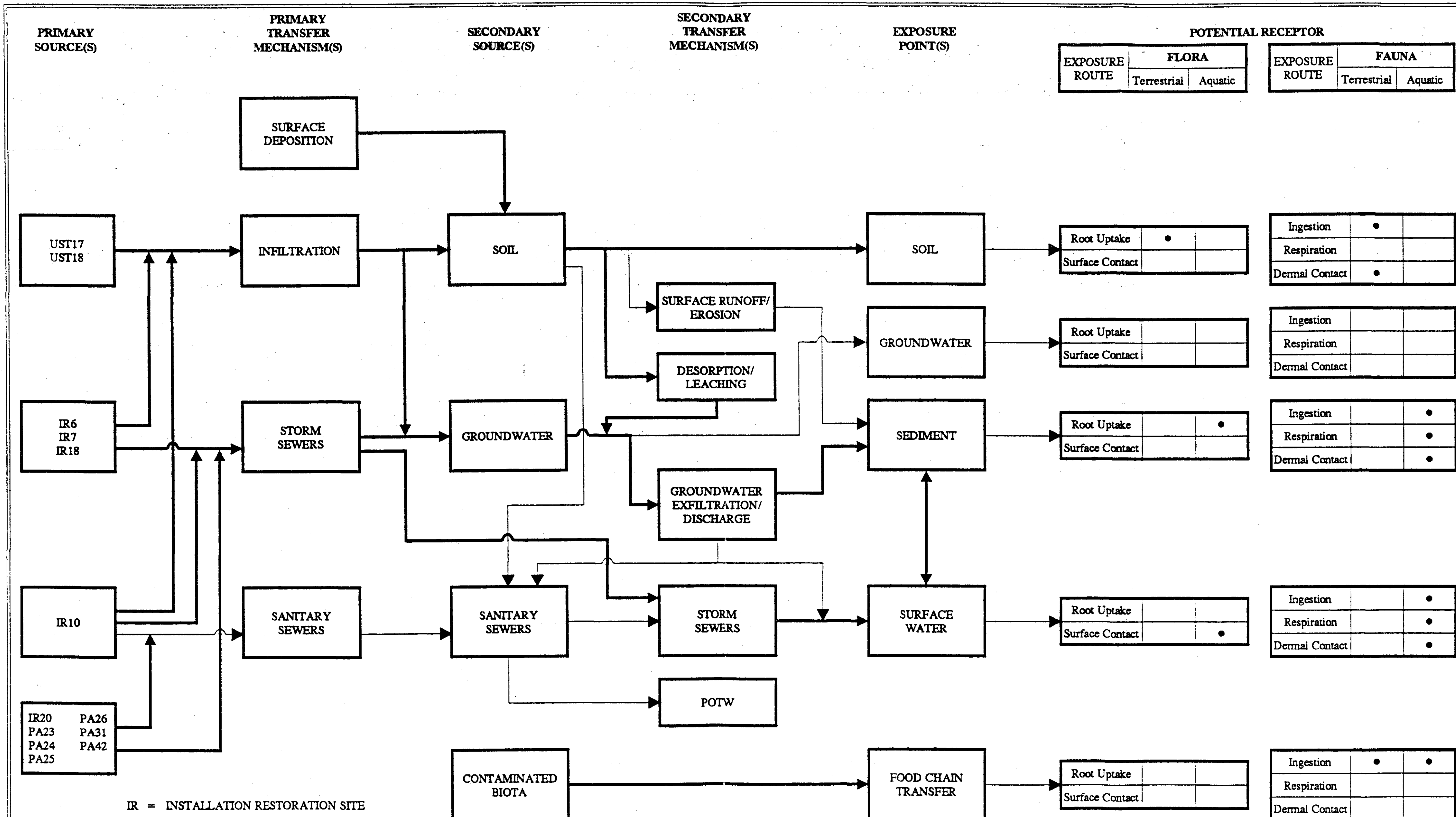


FIGURE 3

TERRESTRIAL FOOD WEB
HUNTERS POINT ANNEX



IR = INSTALLATION RESTORATION SITE

PA = PRELIMINARY ASSESSMENT SITE

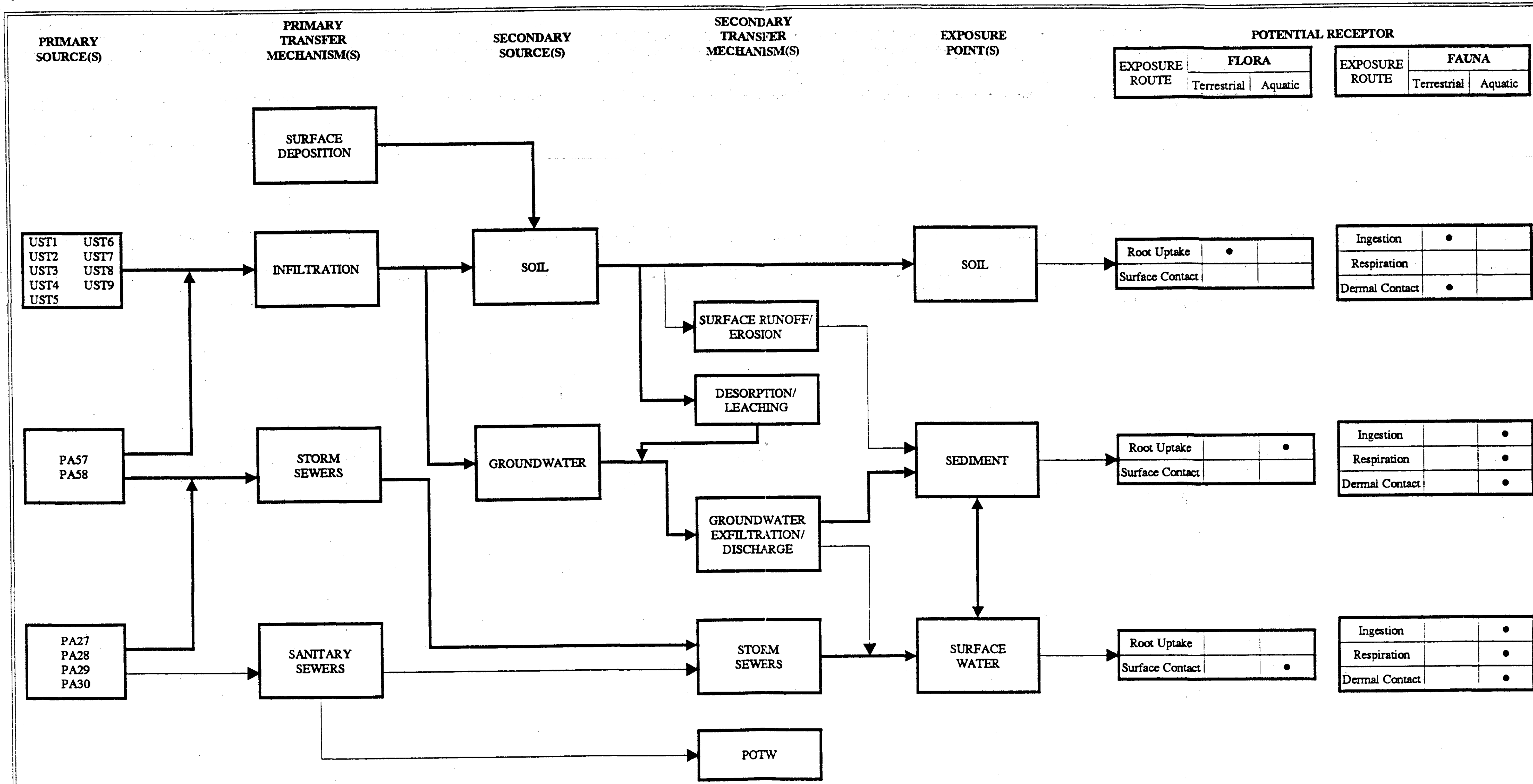
USTS = UNDERGROUND STORAGE TANK SITE

INDICATES POTENTIAL MAJOR RELEASE PATHWAY

INDICATES MINOR RELEASE PATHWAY

FIGURE 4

HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT
PARCEL B GENERAL CONCEPTUAL ECOLOGICAL MODEL



IR = INSTALLATION RESTORATION SITE

PA = PRELIMINARY ASSESSMENT SITE

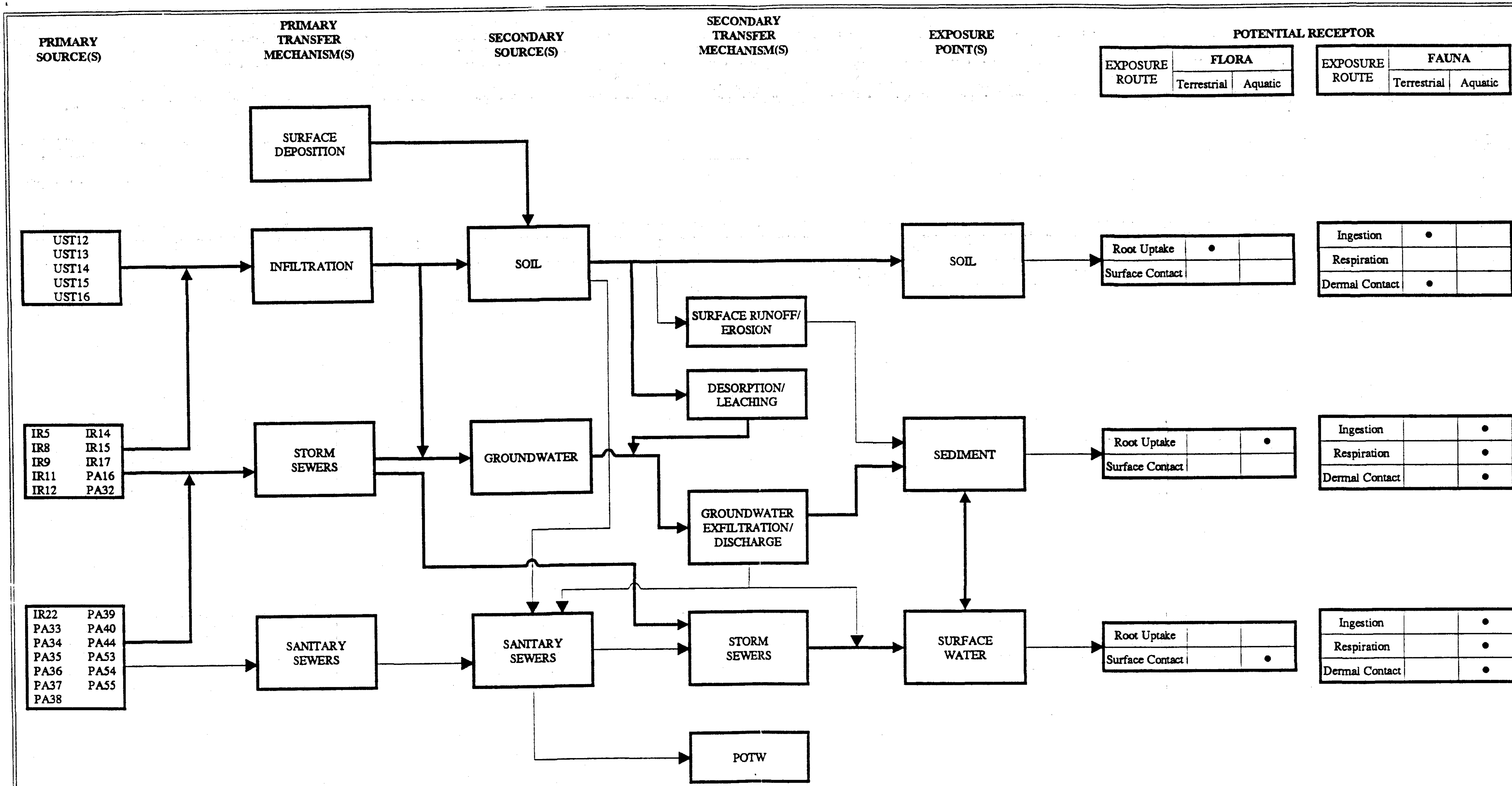
USTS = UNDERGROUND STORAGE TANK SITE

INDICATES POTENTIAL MAJOR RELEASE PATHWAY

INDICATES MINOR RELEASE PATHWAY

FIGURE 5

HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT
PARCEL C GENERAL CONCEPTUAL ECOLOGICAL MODEL



IR = INSTALLATION RESTORATION SITE

PA = PRELIMINARY ASSESSMENT SITE

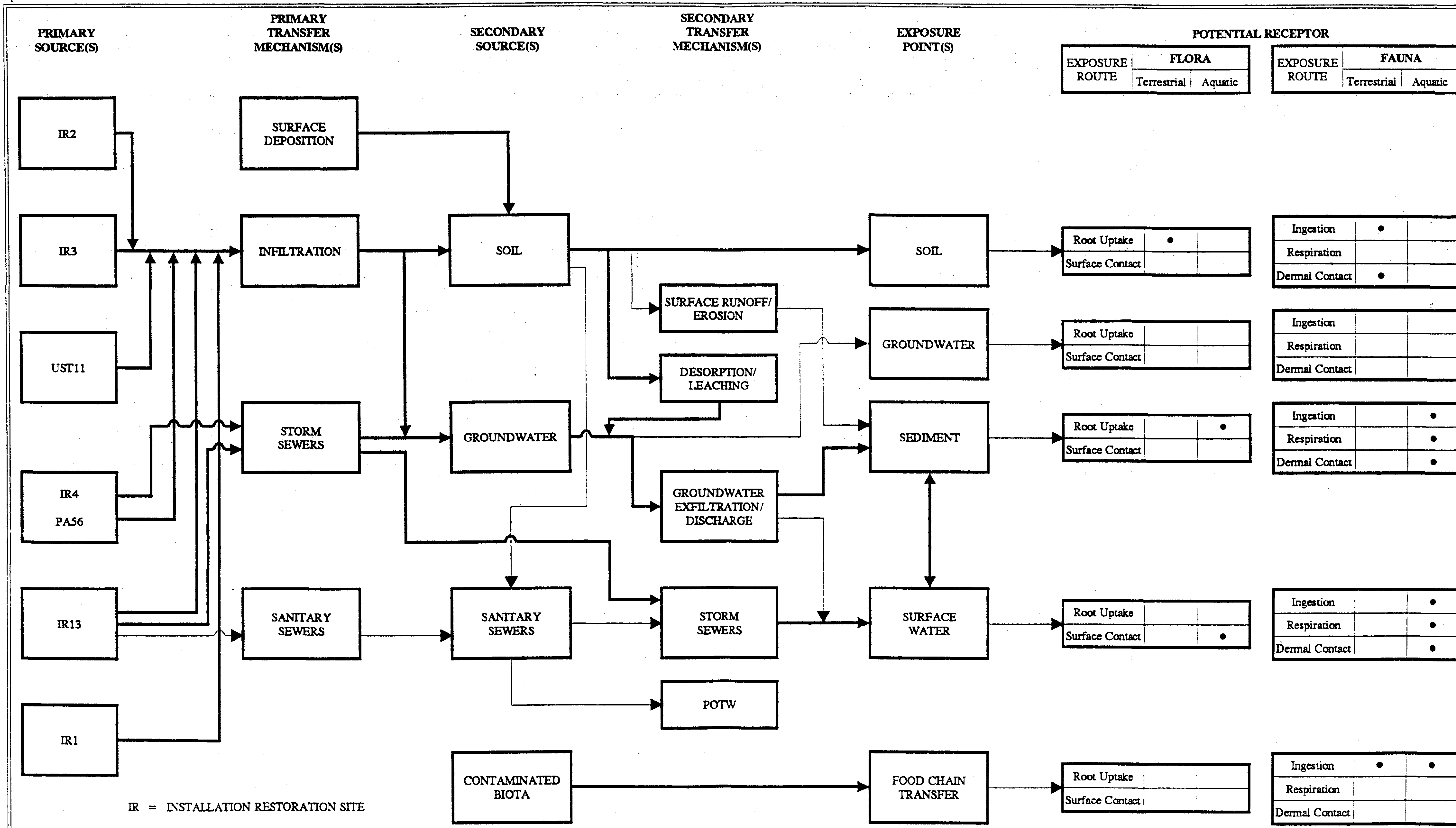
USTS = UNDERGROUND STORAGE TANK SITE

→ INDICATES POTENTIAL MAJOR RELEASE PATHWAY

→ INDICATES MINOR RELEASE PATHWAY

FIGURE 6

HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT
PARCEL D GENERAL CONCEPTUAL ECOLOGICAL MODEL



IR = INSTALLATION RESTORATION SITE

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→ INDICATES POTENTIAL MAJOR RELEASE PATHWAY

→ INDICATES MINOR RELEASE PATHWAY

FIGURE 7
HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT
PARCEL E GENERAL CONCEPTUAL ECOLOGICAL MODEL

STF-WEB.DWG -- 06/10/94 -- CFK -- 044--0254IRRIRK

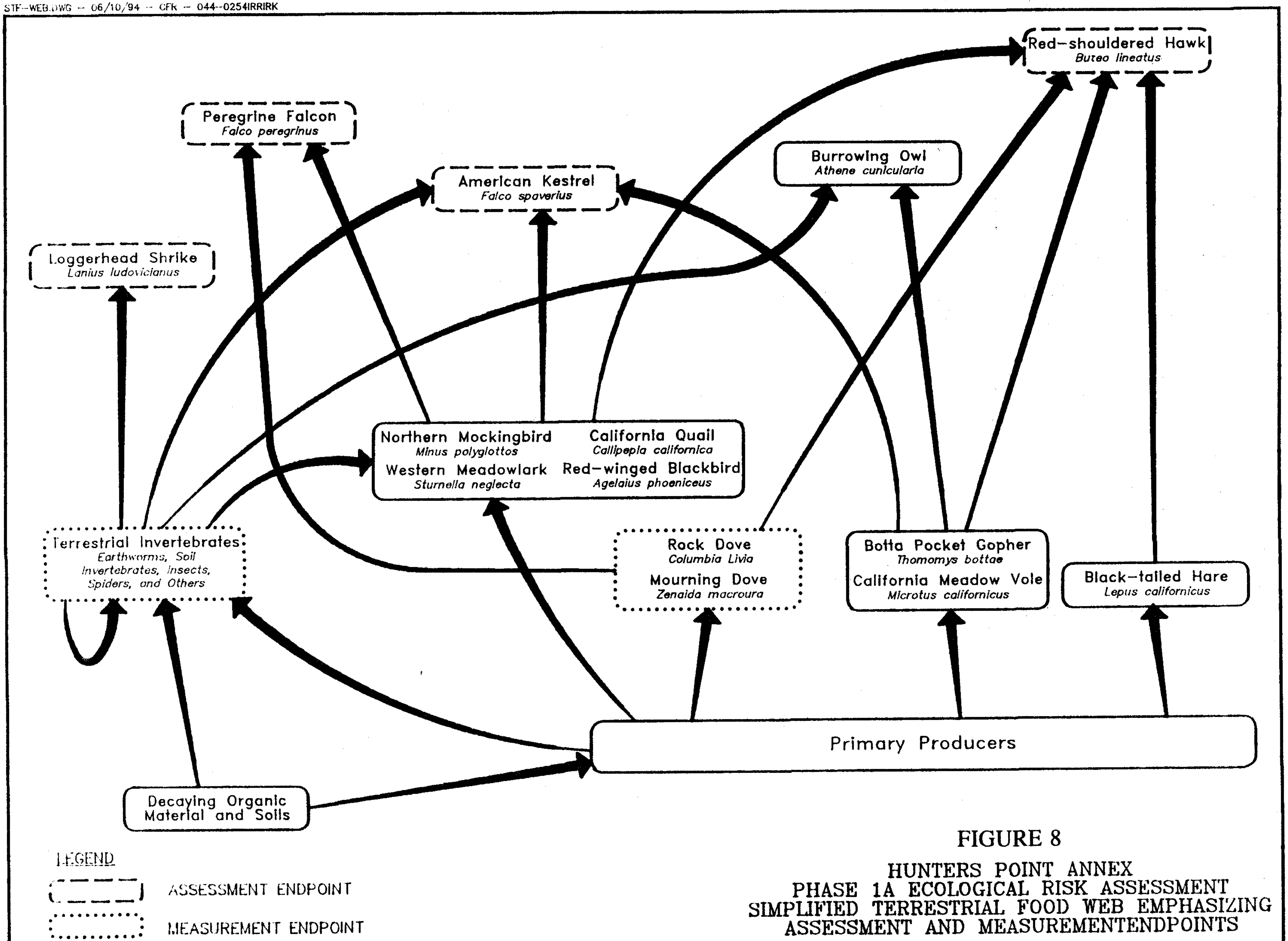
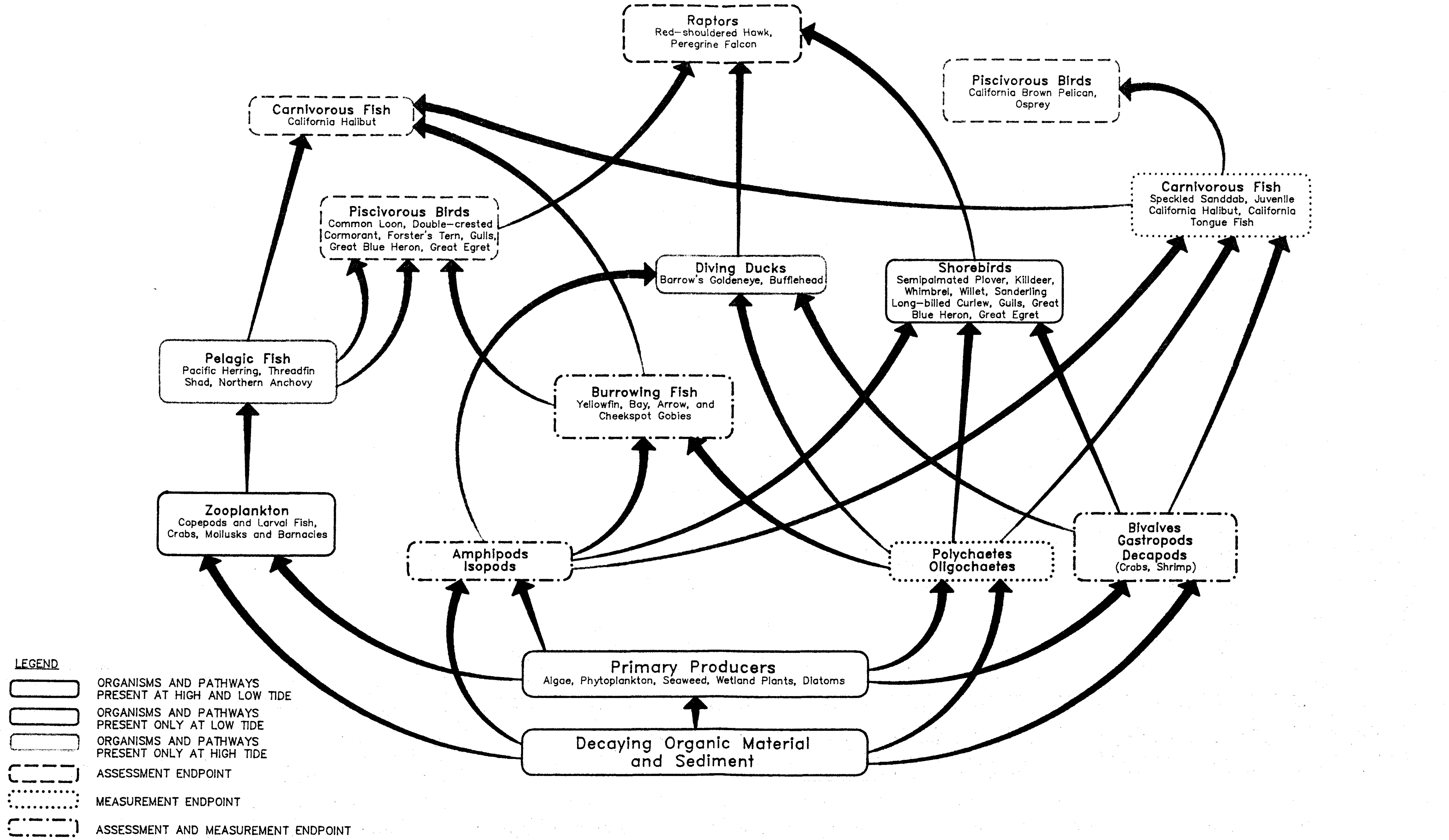


FIGURE 8

HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT
SIMPLIFIED TERRESTRIAL FOOD WEB EMPHASIZING
ASSESSMENT AND MEASUREMENTENDPOINTS



NOTES: SCIENTIFIC NAMES FOR FOOD WEB ORGANISMS APPEAR IN THE TEXT.

PREDOMINANT FOOD WEB INTERACTIONS ARE REPRESENTED.

FIGURE 9

HUNTERS POINT ANNEX
PHASE 1A ECOLOGICAL RISK ASSESSMENT
SIMPLIFIED INTERTIDAL FOOD WEB EMPHASIZING
ASSESSMENT AND MEASUREMENT ENDPOINTS

SF-WEB.DWG - 06/14/94 - CFR - 044-0254IRRIRK

TABLE 1
CONTAMINANTS OF POTENTIAL CONCERN

COPCs for Soil Ingestion and Soil Contact Exposure Routes	
• Trace Metals	• PAHs
Antimony	Anthracene
Arsenic	Benzo(a)anthracene
Barium	Benzo(a)pyrene
Chromium	Benzo(b)fluoranthene
Cobalt	Benzo(g,h,i)perylene
Copper	Benzo(k)fluoranthene
Lead	Chrysene
Manganese	Fluorene
Mercury	Indeno(1,2,3-cd)pyrene
Molybdenum	Phenanthrene
Nickel	2-methylnaphthalene
Vanadium	Fluoranthene
Zinc	Naphthalene
• Arochlor - 1254	
• Arochlor - 1260	
• 4,4'-DDT	
• 4,4'-DDE	
• 4,4'-DDD	
COPCs for Above Groundwater Soils to Surface Water Pathway	
• All Trace Metals with RWQCB Soil Values	
Arsenic	Cyanide
Cadmium	Total PAH
Chromium (total)	Total PCB
Copper	Total DDT
Lead (total)	Heptachlor epoxide
Mercury	Total chlordane
Nickel	Pentachlorophenol
Selenium	
Silver	
Zinc	

TABLE 1
CONTAMINANTS OF POTENTIAL CONCERN (Continued)

COPCs for Below Groundwater Soils to Surface Water Pathway

- All Trace Metals with RWQCB Soil Values

Arsenic	Cyanide
Cadmium	Total PAH
Chromium (total)	Total PCB
Copper	Total DDT
Lead (total)	Fluoranthene
Mercury	Pentachlorophenol
Nickel	Total chlordane
Selenium	Total endrin
Silver	Total endosulfan
Zinc	Heptachlor
	Heptachlor epoxide
	1,4-Dichlorobenzene
	Dieldrin
	Aldrin
	Beta-BHC
	Pentachlorophenol

Groundwater COPCs

- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc

- Cyanide
- Total Endrin
- Total PCBs
- Total DDT
- Heptachlor
- Toxaphene
- Pentachlorophenol
- Bis(2-ethylhexyl)phthalate

- Anthracene
- Fluorene
- Phenanthrene
- Pyrene
- Acenaphthene
- Fluoranthene
- Naphthalene

- Acenaphthylene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g.h,i)perylene
- Chrysene
- Fluorene
- Indeno(1,2,3-cd)pyrene

TABLE 1
CONTAMINANTS OF POTENTIAL CONCERN (Continued)

Offshore Sediment COPCs	
• Antimony • Arsenic • Cadmium • Chromium • Copper • Lead • Tributyltin • Low Molecular Weight PAHs Naphthalene Fluorene Anthracene Phenanthrene Acenaphthylene Fluoranthene Pyrene Benzo(k)fluoranthene Acenaphthene Benzo(g,h,i)perylene 1-methylnaphthalene • DDT • DDE • DDD • Dieldrin • Endrin • Chlordane (alpha and gamma isomers) • PCBs	• Manganese • Mercury • Nickel • Silver • Vanadium • Zinc • High Molecular Weight PAHs Chrysene Benzo(a)anthracene Indeno(1,2,3-CD)pyrene Benzo(b)fluoranthene Dibenzo(a,h)anthracene Benzo(a)pyrene
COPCs for Stormwater	
• Copper • Lead • Zinc • Tributyltin	
COPCs for Surface Water	
• Tributyltin	

TABLE 2
SUMMARY OF PROPOSED ASSESSMENT AND MEASUREMENT ENDPOINTS

Assessment Endpoint	Measurement Endpoint
Terrestrial	
Protection of habitat at HPA used by the avian species peregrine falcon, American kestrel, red-shouldered hawk, and loggerhead shrike	Plant bioaccumulation studies Earthworm and soil arthropod bioaccumulation and tissue residue studies Mourning and rock dove and small mammal tissue residue studies
Aquatic	
Protection of habitat at HPA used by the avian species California brown pelican, double-crested cormorant, Barrow's goldeneye, and great blue heron Protection of habitat for and HPA populations of California halibut and the, arrow, and bay gobies	Mollusk and crustacean bioaccumulation and tissue residue studies Fish bioaccumulation and tissue residue studies
Protection of habitat for and HPA populations of mollusks, crustaceans and annelids at HPA	Mollusk, crustacean, and annelid toxicity, growth, and reproduction studies Mollusk and crustacean bioaccumulation and tissue residue studies

TABLE 3
ABUNDANT SUBTIDAL AND INTERTIDAL INVERTEBRATES

REPRESENTED SPECIES[a]	IMPORTANT LIFE HISTORY CHARACTERISTICS
Annelids	
Oligochaetes *Tubificidae* spp.	• Intertidal or subtidal benthic animals live within and feed upon bottom deposits. • Larger species burrow freely in the substrate and probably feed indiscriminately on the sediment. • Very small species are meiobenthic (interstitial) worms which inhabit the interstices between substrate particles and feed on fine, organic debris. • Free-burrowing species tend to live in silts and poorly sorted, fine sands; meiobenthic worms are more restricted to coarser sands. • Particularly abundant in areas of organic enrichment.
Polychaetes *Cirrifornia spirabrancha* *Exogone lourei* *Glycinde polygnatha* *Nereis succina*	• Occur in all ocean environments. • Some are planktonic throughout life, but most species and adults are benthic, dwelling on or in the bottom at various depths • Some are carnivorous predators, some are herbivores, and others may be omnivorous, scavengers, filter feeders, or deposit feeders. • Are preyed upon by great variety of invertebrates and shorebirds.

TABLE 3
ABUNDANT SUBTIDAL AND INTERTIDAL INVERTEBRATES (Continued)

REPRESENTED SPECIES[a]	IMPORTANT LIFE HISTORY CHARACTERISTICS
Crustaceans	
Amphipods *Ampelisca abdita* *Caprella scaura* *Corphium spp.* *Grandierela japonica* *Rhincotropis spp.*	• Among the most abundant crustaceans in the intertidal zone of California. • The majority of described species are benthic. • Amphipods living on sandy beaches are active burrowers. Others living on more solid substrata in the intertidal zone build more permanent tubes of mud or debris. • Most appear to be scavengers or detritus feeders, but some consume tiny plants growing on rockweed and kelp, and a few capture and eat small animals such as copepods and bryozoans.
Decapods *Hemigrapsus oregonensis* *Hemileucon hinumensis*	• Common throughout San Francisco Bay, occurring in open mud flats, mats of green alga, and beds of eelgrass in high to low intertidal zones. • Preyed upon by shorebirds. • Are primarily herbivores, feeding on diatoms and green algae but can be carnivorous if meat is available. • Are skilled burrowers and bury themselves rapidly to escape predators.
Isopods *Cirolina harfordi* *Gnoriphaeroma spp.* *Sphaeroma pentodon*	• Predominantly benthic,though a few are planktonic. • Occur in intertidal zone where they hide in worm tubes, seaweeds, and sessile animals. • Form important intermediate links in the food chain as herbivores, prey, predators, parasites, scavengers, and detritus feeders. • Salinity, temperature, and humidity are physical factors that influence distribution.

TABLE 3
ABUNDANT SUBTIDAL AND INTERTIDAL INVERTEBRATES (Continued)

REPRESENTED SPECIES[a]	IMPORTANT LIFE HISTORY CHARACTERISTICS
Mollusks	
Bivalves *Cryptomya californica* *Gemma gemma* *Macoma balthica* *Musculista senhousia* *Mya arenaria* *Mylitus edulis* *Potanocorbula ameurensis* *Tapes japonica*	• Exist as free-living infaunal burrowers or nestlers or are epifaunal, attaching to the substrate by cementation or a byssus. • Predominantly filter feeders. • Occur in dense populations on rocky shores, pilings, or soft substrates. • Preyed upon by shorebirds as well as harvested by humans.
Gastropods *Odostomia fetella*	• Commonly found in bay mudflats. • Preyed upon by shorebirds.

Notes:

[a] Top 20 to 25 percent most abundant invertebrate taxa caught at HPA in the intertidal and subtidal surveys conducted by Biosystems and the shrimp and crab surveys conducted by California Department of Fish and Game.